IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Serial No. 10/735,599 Filed December 12, 2003
(Attorney Docket No. GP-302982)

Frank Ament Group 3748

EXHAUST EMISSION AFTERTREATMENT Examiner Binh Q. Tran

AFFIDAVIT UNDER 37 CFR 1.131

Commissioner for Patents
PO Box 1450
Alexandria VA 22313-1450

Frank Ament, being duly sworn, deposes and says:

1. I am an inventor of claims 1-9 of the patent application identified above and an inventor of the subject matter described and claimed therein.

2. Prior to November 20, 2002 having earlier conceived of the idea for the claimed invention "Exhaust Emission Aftertreatment," and with due diligence, I reduced the invention in the United States as evidenced by the attached invention disclosure form and documentation. The dates have been redacted from the invention disclosure and documentation.

3. That all statements made above of my own knowledge are true, that all statements made above on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under title 18 United States Code, Section 1001 and may jeopardize the validity of the application or any patent issuing thereon.

Frank Ament

Frank Ament

Subscribed and sworn to before me this 13th day of September, 2005.

Lillian M. Dodge

Notary Public

LILLIAN M. DODGE
Notary Public, Macomb County, MI
My Commission Expires May 5, 2006

General Motors Corporation
Legal Staff
300 Renaissance Center
Mail Code 482-C23-B21
PO Box 300
Detroit MI 48265-3000

Attachment

CONFIDENTIAL AND PRIVILEGED

RECEIVED

GENERAL MOTORS CORPORATION

BY: S.R. Koubek

No. GP-302982
PTE2002170

RECORD OF INVENTION

This Record of Invention must be completed with sufficient detail so that your invention can be understood and evaluated by both your engineering management and by a GM Legal Staff patent attorney. Novelty and competitive significance of your invention will be evaluated based on the information you provide.

Invention Title: On-Board Gasoline POx Reformer for Diesel Lean NOx Catalyst Regeneration

Inventor #1

Name: Frank (First Name) | (Middle Initial) | Ament (Last Name) Citizen of: US

Social Security No. 364-48-6406 GM Employee: ☒ Yes ☐ No ☒ Salary ☐ Hourly ☐ Contract

Home Address: 1681 Rollingwoods Dr. (Street) Troy (City and State) MI (Zip Code)

GM Unit: Powertrain GM Phone No. (8)- (Centrex Number) 586-634-9888 (Area Code) + Number

GM Address: 3300 General Motors Rd. Mail Code: 483-331-500 FAX Number: (8)-341-1808 (Centrex Number)

Non-GM Employer: Phone No. (Area Code) + Number

Non-GM Employer Address: (Street) (City and State) (Zip Code)

Inventor #2*

Name: (First Name) | (Middle Initial) | (Last Name) Citizen of:

Social Security No. GM Employee: ☐ Yes ☐ No ☐ Salary ☐ Hourly ☐ Contract

Home Address: (Street) (City and State) (Zip Code)

GM Unit: GM Phone No. (8)- (Centrex Number) (Area Code) + Number

GM Address: Mail Code: FAX Number: (8)- (Centrex Number)

Non-GM Employer: Phone No. (Area Code) + Number

Non-GM Employer Address: (Street) (City and State) (Zip Code)

* If there are more than two (2) inventors for this invention use the template at the end of this form.

Answer questions 1 - 8, completing all of them to the best of your knowledge.

1. This invention was first thought of on: _____

2. This invention has been or is expected to be disclosed outside GM on: _____

3. This invention has been used or is committed to be used in production on: no

4. This invention has been offered for sale outside GM on: no

5. Was this invention made while working on a Government Contract? ☐ Yes ☒ No

   If yes, identify the government Contract No. _____

6. Identify the product or process in which the invention is incorporated: _____

7. List all individuals who can provide information about the making of the invention. This list may include individuals who made the first sketch, descriptio or tests and individuals who are familiar with the facts relating to the making of the invention.
   First proposed to Gary Smyth or rd as a possible joint development activity between GM Powertrain and Delphi..

8. Each inventor has a legal duty to disclose all information known that is material to patentability of this invention. Such information includes the relevant prior art, which may be in the form of current or past products, equipment, processes, materials, patents, publications, advertisements, displays, and unpublished developments and proposals—whether originated by you, others in GM, competitors, suppliers, customers or others. Such information also includes disclosure of this invention outside GM, sales and offers of products using this invention, use of this invention in production and disputes about who should be considered as an inventor of this invention. To comply with the duty to disclose, list here and attach a copy of all such information, to the extent known.
   Not Aware of any.

Answer question 9 thoroughly.

9. Describe the invention in sufficient detail so that its nature, operation and usefulness can be understood. (Attach drawings, diagrams and further description, when necessary. Additional guidelines are listed below.)

Diesel NOx emissions reduction is a difficult challenge, especially under high load conditions. Several Lean NOx reduction technologies are being investigated. The leading candidates are Urea Selective Catalytic Reduction (SCR) and Lean NOx Trap Catalysts.

Urea SCR is basically an "add-on" system that uses established catalysis and has minimum impact on engine calibration and operating mode. The Urea SCR system does require a large, specialized catalyst, and an entire Urea supply & dosing system. While the NOx emissions reduction is promising, even at higher loads, the lack of Urea fueling infrastructure remains a major roadblock. Additionally, on-board Urea storage, freezing, exhaust mixing and Ammonia breakthrough remain development issues.

Although Lean NOx Traps do not require a secondary fuel supply, the NOx emissions performance is more limited and the impact on engine calibration and operating mode is severe. The Lean NOx Trap technology is similar to that used for Gasoline Direct Injection Systems. The catalyst requires rich exhaust spikes every few minutes to reduce the stored NOx emissions. Generating "rich diesel exhaust" is very difficult. Operating at mixtures richer than about 18 Air-Fuel Ratio, causes rapid increases of Soot formation and degrades combustion stability. The current methods of generating rich reductants is to inject excess fuel late in the expansion stroke, or inject diesel fuel directly into the exhaust pipe. Both methods have significant drawbacks. The "forced" rich exhaust spikes also cause very high HC emissions that are very difficult to clean-up. Lean NOx Traps face additional challenges under high load operation, where the NOx formation rate is high, and the catalyst residence time is low.

While the on-board reductant is more attractive from an emissions performance and engine calibration standpoint, the co-fueling infrastructure problem must be overcome. A Urea co-fuel infrastructure for light trucks is unlikely in North America.

Over the years, considerable work has been done on gasoline reforming or Partial Oxidation products generation. The claimed benefits of on-board H2 and CO generation from gasoline include lower cold start emissions and improved fuel efficiency from dilute combustion operation. The benefits were usually outweighed by the added system cost and complexity. In recent years, Fuel Cell development has rekindled the development of on-board gasoline reformers. Supplier-developed Reformer systems have shown improvements in conversion efficiency and feedstream response. There are also claims of near-term production availability.

* * * * * * * * * *

This invention uses an on-board gasoline reformation system to provide exhaust reductants for diesel Lean NOx Catalyst regeneration. Since the reductant feedstream is generated independent of the diesel engine, there would be minimum compromise to diesel engine efficiency or operating mode. This approach is similar to the Urea SCR system, in that it requires co-fueling, but the big advantage is the gasoline and diesel infrastructure already exists. A co-fueling nozzle, similar to the urea design, can be used to fill both fuels at the re-fueling stations.

Gasoline Reformer System architecture and controls requirements can be worked-out based on the specific diesel engine/vehicle application.

Answer the following questions if helpful in describing this Invention

10. What benefits will be realized by using this invention?

Enables Diesel Lean NOx Trap emissions control.
Current methods of generating diesel exhaust reductants result in severe compromises in emissions performance, fuel efficiency and vehicle operation.

The H2, CO and HC by-products from gasoline reforming are well-understood and consistent with current catalyst performance. No additional Particulates or heavy HC are formed. HC from excessively rich diesel exhaust has proven difficult to clean-up.
Urea SCR requires larger volumes of unique catalyst chemistry, with the additional concerns of Ammonia breakthrough.

11. What is the state of development of this invention?

Delphi has demonstrated a Gasoline Reformer System.
Claims to be beyond Ph00 , into Ph 1

Looking at potential Adv PT - Delphi vehicle system development activity for .

12. To the extent known, what alternatives exist for accomplishing substantially the same result as this invention?
Described in 9 above.

13. Describe the background of the invention. This description may include the state of the prior art and may identify deficiencies in the prior art that are overcome by this invention.
Leverage the advances in Gasoline Reformer development and apply to the Diesel rich exhaust reductant problem.
Leverage the Urea co-fueling nozzle development work (done by Ford) and apply to co-deliver gasoline with diesel fuel.

This concept tries to capitalize on two areas of development, that separately have little chance of high- volume production, and brings them together in a unique way to solve the Diesel Lean NOx emissions problem.

Far more achieveable than Urea co-fueling

I hereby assign this invention to General Motors Corporation and authorize General Motors Corporation to file an application on my behalf.

Frank Ament FRANK AMENT

INVENTOR – SIGNATURE **(ALSO, PRINT NAME)** **DATE**

INVENTOR – SIGNATURE **(ALSO, PRINT NAME)** **DATE**

INVENTOR – SIGNATURE **(ALSO, PRINT NAME)** **DATE**

This invention was reviewed and understood by me:

J. G. SMYTH

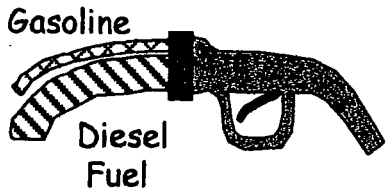
1st WITNESS – SIGNATURE **(ALSO PRINT NAME)** **DATE**

DAVID BROWN

2nd WITNESS – SIGNATURE **(ALSO, PRINT NAME)** **DATE**

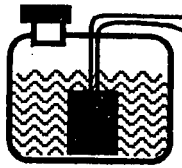
Gasoline POx Reductant System for Diesel Aftertreatment

Dual-Fuel Dispensing Nozzle



On-Board Gasoline Supply

Capacity : ~ 5% of Diesel Fuel Volume



Fuel Pump & Press Control

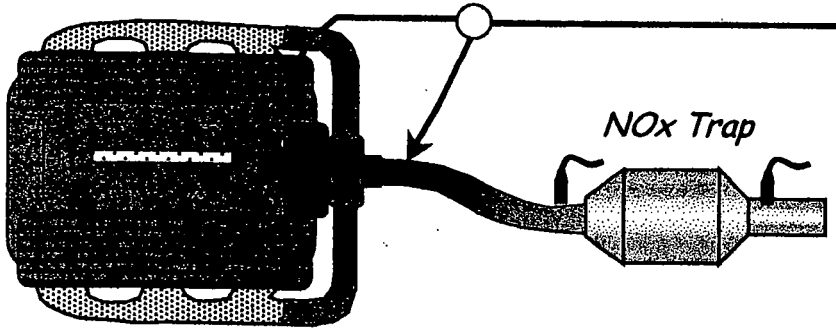
Partial Oxidation Reformer

Gasoline Injection

Air or Exhaust

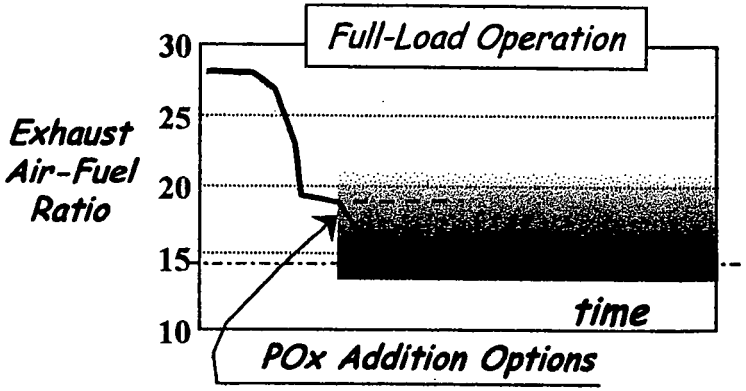
(25% 26% 49%) $H_2 + CO + N_2$ + Heat

Flow Control Valve



Features:

- Separate, add-on Reductant System
- Independent of Engine Operation
- Established gasoline infrastructure
- Uses production-type components



- *Into Exhaust feedstream ahead of NOx Trap*
- *Into Engine to improve Stoich Combustion Tolerance*
- *Controlled flow to Both locations*